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DETERMINATION OF THE LOCATION FOR AN AREA SCHOOL.
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TWO MODELS ARE PRESENTED TO AID PLANNERS IN SELECTING THE SITE FOR AN AREA SCHOOL WHICH IS MOST EFFICIENT IN MINIMIZING TIME AND COSTS OF TRANSPORTING STUDENTS. THE FIRST MODEL DEALS WITH THE RELATIONSHIP OF SCHOOL SITE AND BUS TRANSPORT PROBLEMS. SOLUTION TO THE SITE PROBLEM IS FOUND BY COMPUTING A LOCATION COEFFICIENT FOR EACH POTENTIAL SITE USING TRANSPORT INPUTS AND TIME-DISTANCES. THE SECOND MODEL PROVIDES A SOLUTION FOR THE COMMUTER POST-SECONDARY EDUCATIONAL INSTITUTION. ECONOMIC EFFICIENCY OF ANY POTENTIAL SCHOOL LOCATION SITE WILL BE DEPENDENT UPON SPATIAL DISTRIBUTION OF STUDENTS, GEOGRAPHICAL TERRAIN, URBAN-RURAL CHARACTERISTICS OF THE REGION, AND NATURE OF ROADS AND ROADWAY NETWORKS. THIS PAPER WAS PRESENTED AT THE WESTERN REGIONAL SCIENCE ASSOCIATION MEETINGS (LAS VEGAS, JANUARY 27-29, 1967). (HW)

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DETERMINATION OF THE LOCATION FOR AN AREA SCHOOL*

Jeanne Dost

I.

Society has become increasingly concerned about educational deprivation of youth in both urban and rural areas.[1] This recognition is concurrent with increased competition of other social needs for resources. In such circumstances it is particularly important that plans for expanding educational expenditures reflect considerations of economic efficiency.

Although federal funds have been provided to help school districts build area schools, decision-makers in education lack methodology for determining the best site for a school. Availability of objective guidelines could help prevent arbitrary and inefficient solutions to the area school location problem.

A model is presented in this paper to give educators and school systems a means for determining the most efficient site for an area school. Although no procedures have been developed for locating a school when the service area is defined, Isard has presented methods for analyzing determination of the most desirable administrative area given the location of a school.[2] Unfortunately he does not provide a solution to the problem. Correa has dealt with the question of optimum size and number of schools in terms of cost per student.[3] However, he assumes that quality of education is constant, at a time when, at least in this country, the quality of education is rapidly changing.

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[1] E. g. Social Dynamite: The Report of the Conference on Unemployed, Out-of-School Youth in Urban Areas. Washington, Nat. Comm. for Children and Youth, 1963. Rural Youth in Crisis: Facts, Myths, and Social Change. Washington, U. S. Dept. of Health, Education and Welfare, 1964.

[2] Walter Isard. Methods of Regional Analysis: An Introduction to Regional Science, pp. 527-533. Cambridge, Mass., The M.I.T. Press, 1960.

[3] Hector Correa. Optima for the Size and Number of Schools. Scientia Paedagogica Experimentalis, III, 1, 5-15.

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II.

The purpose of this paper is to present an adaptation of comparative cost techniques for location determination of the transport-oriented plant to solving the problem of locating an area school based on a variation of Weberian methodology. Economic efficiency of any potential school location site will be dependent upon the spatial distribution of students, geographical terrain of the area, urban-rural characteristics of the region, and the nature of the roads and roadway networks. All these factors can be taken into consideration by a location coefficient computed for each potential site point.

The model will enable decision-makers to select that location at which regional education can be provided at minimum cost to youths dispersed over a wide area. The solution provided by the model maximizes the use of available educational resources by minimizing those costs assumed to vary with location --- time and transport costs of moving students to and from the school. The significance of this assumption is examined in the last section.

The model for solving the location problem in the case where only three alternative sites exist and school buses transport students is set forth in Section III. The general model for the bus transport case is developed in Section IV and transformed in Section V to handle the site problem of the commuter post-secondary educational institution.

III.

This model is posited on the assumption that the only variations in regional education costs created by changing school sites are changes in time and costs of transporting students to and from school. While time is generally treated as a non-monetary factor, it is included here as one determinant of the location of an area school by use of a time-distance factor. This methodology allows for the disutility of greater travel times so that of any two sites with identical transport costs, the optimum site would be that for which student travel time was less.

Travel time is taken into consideration by use of the concept of time-distance rather than geographical distance. This concept can best be explained by example. Where each of three sites are being considered as locations for an area school, assume sites b and c are each 20 miles from point a. However, the road between b and a is a freeway and no stops must be made to load (unload) students. Therefore, time for a school bus to travel from b to a is, say, 30 minutes. On the other hand, the road between c and a crosses mountain terrain and the school bus has to make a number of stops. Thus, it takes this bus one hour to travel from c to a. Comparisons of simple road distances would indicate points b and c to be equi-distant from site a. The

concept of time-distance takes into account that it takes twice the time to travel from c to a as from b to a; the time-distance from c to a is twice that between b and a.

The formula for computing time-distance between i and j is:

$$\frac{t_{ij}}{m_{ij}} = p_{ij}$$

where:

t_{ij} = minutes of bus (automobile) travel time between any two points, i and j

m_{ij} = number of miles between points i and j

p_{ij} = minutes per mile for trip between i and j

so that

$$p_{ij} m_{ij} = d_{ij}$$

where:

d_{ij} = time-distance between any two points, i and j.

Transport inputs are the costs per mile for a bus to travel between any two points. Transport inputs are computed per bus rather than per student as it costs as much for the bus to travel between any two points whether or not it is filled to passenger capacity, since it can be assumed the school bus will make the trip even at times when some students are unable to go to school.[4]

These two factors, time-distance and transport inputs, are used to compute a location coefficient for each of the three potential sites.

Where alternative inter-point routes exist, only that for which transport input times time-distance is least would be used in computing the location coefficient. The location coefficient for point a is:

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[4]This is not strictly true since operating and maintenance costs of each bus will depend on the number of stops which in turn is a function of the number of passengers.

$$L_a = 2x(r_{ab}\, d_{ab}) + 2x(r_{ac}\, d_{ac})$$

where:

$2x$ = number of school buses making trips twice daily

r_{ab} = transport input for moving students from a to b

d_{ab} = time-distance between a and b

r_{ac} = transport input for moving students from a to c

d_{ac} = time-distance between c and a.

It follows then that total costs of an area school are minimized when the area school is so located that time and costs of transporting the student to and from the area school are minimized. The optimum location site would be at point a when:

$$L_c > L_a < L_b.$$

Ceteris paribus, total costs of the area school are minimized when the location coefficient for site a is less than the location coefficients of either b or c.

IV.

Where the number of possible alternative locations is larger than three, any potential site is designated by the subscript i, where i = 1...n, n being the number of alternative locations.[5] The location coefficient for any point i is:

$$L_i = 2x(r_{i1}\, d_{i1}) + 2x(r_{i2}\, d_{i2}) + ... + 2x(r_{i(n-1)}\, d_{i(n-1)})$$

where:

r_{i1} = transport input for moving students from point i to alternative 1

d_{i1} = time-distance from point i to alternative 1

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[5] In the case of strip cities, sites at either end of city would be treated as alternative sites.

r_{i2} = transport input from point i to alternative 2

d_{i2} = time-distance between point i and alternative 2

$r_{i(n-1)}$ = transport input from point i to final alternative n-1

$d_{i(n-1)}$ = time-distance between any point i and final alternative n-1.

Optimum location site, o, is given by location coefficient for point o which is less than the location coefficient for any other site i. Thus, the tentative equilibrium condition for the optimum location site in a single region is:

$$L_o < L_i.$$

V.

The model presented in this section treats the more common situation of the post-secondary educational institution where students provide their own transportation. Transport input is the cost per mile for a student to travel between any two points. The location coefficient for any point i is:

$$L_i = 2s_1 (r_{i1} d_{i1}) + 2s_2 (r_{i2} d_{i2}) + \ldots . 2s_{n-1} (r_{i(n-1)} d_{i(n-1)})$$

where:

s_1 = number of students traveling to an area school at point i from point 1

r_{i1} = transport input for a student to travel from some point i to alternative 1

d_{i1} = time-distance from point i to alternative 1

s_2 = number of students traveling to an area school at site i from point 2

r_{i2} = transport input for a student to travel from point i to point 2

d_{i2} = time-distance from point i to alternative site 2.

s_{n-1} = number of students traveling to site i from final alternative site n-1

$r_{i(n-1)}$ = transport input for a student to travel from point i to final alternative site n-1.

Optimum location site will be that site for which time-distance and transport costs of student travel will be minimized, site o. Where the location coefficient for site o is less than the location coefficient for any other alternative location, site i:

$$L_o < L_i.$$

VI.

The limitations of the model relate to the treatment of the area school as a transport-oriented firm where only transport costs for students are considered. It may be that in some cases where reallocation of resources is planned rather than additional expenditures, it would be necessary to take into account the transport inputs of teachers and administrators.

There may be sites at which an area school would reap certain economies of production. For example, where instructional and administrative funds could be reduced by sharing teachers and administrators with a community college, technical institute or college located in the immediate vicinity. In remote rural areas, it may be that salaries have to be relatively higher to attract teachers, an example of diseconomies of production associated with particular sites.[6] An urban area may have a distinct comparative advantage as a competitive site because school facilities can be used for secondary purposes such as community meetings, adult education programs or civic activities.

While these factors suggest opportunities for further exploration of the area school location problem, the framework of the model does expose factors of economic efficiency and objective measurements for implementing educational planning.

It also provides educational planners with a yardstick for comparing the significance of building cost differentials among sites such as the greater initial cost of sewage in one site or the comparative importance of operating costs when the differentials are small as in the case where fire protection costs are moderately greater for one site.

The model developed in this paper provides the decision-makers with

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[6] This would be a factor only in post-secondary institutions.

economic criteria for choosing among potential area school sites. However, any policy decision must also be based on consideration of the non-monetary comparative advantages of the various locations. Use of the proposed model would help reduce individual biases and the use of guesswork in making such decisions. Furthermore, these measurements would lay bare where decision-making was based on empirical foundation and where it was founded on experience or hunches.

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ABSTRACT

Although federal funds have been provided to help school districts build area schools, decision-makers in education lack methodology for determining the best site for a school. Economic efficiency of any potential school location site will be dependent upon spatial distribution of students, geographical terrain, urban-rural characteristics of the region, and nature of roads and roadway networks.

The models presented in this paper enable planners to select that location at which regional education will minimize time and costs of transporting students. Solution to the site problem is found by computing a location coefficient for each potential site using transport inputs and time-distances. The first model deals with the site problem in the bus transport case. The second provides a solution for the commuter post-secondary educational institution.